24
$tcpO_2$/$tcpCO_2$ Module Section

This chapter provides information on transcutaneous monitoring of oxygen ($tcpO_2$) and of carbon dioxide ($tcpCO_2$). It also provides information on preparing the transducer for use, and applying the transducer to the patient. This chapter includes the following sections:

- Introduction to the tcpO2/tcpCO2 Parameter Module 24-2
- Activating the Transducer 24-7
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Introduction to the $tcpO_2$/$tcpCO_2$ Parameter Module

What does it Measure?

The $tcpO_2$/$tcpCO_2$ module measures the partial pressure of the oxygen and carbon dioxide that diffuses *transcutaneously* (through the skin). The oxygen measurement is valid for an infant patient who is not under gas anesthesia. These partial pressures provide a measure of the oxygen and carbon dioxide levels in the blood.

How the $tcpO_2$/ $tcpCO_2$ Measurement Works

The $tcpO_2$/$tcpCO_2$ transducer heats the skin. This has the effect of increasing local blood perfusion so that oxygen and carbon dioxide can diffuse to the skin surface more easily.

The transducer contains an electrolyte solution which is held in place by two gas-permeable membranes. The oxygen and carbon dioxide that diffuses out of the skin passes through these membranes into the electrolyte solution where electrochemical reactions take place. These reactions generate electrical signals which are representative of the amounts of oxygen and carbon dioxide present. The electrical signals are measured by the module to enable the $tcpO_2$/$tcpCO_2$ values to be displayed as numerics on the standard display.

Correlation of Transcutaneous with Arterial Blood Gas Values

Transcutaneous measurements are not capable of replacing arterial blood gas monitoring. However, transcutaneous monitoring can be used to reduce the frequency of arterial sampling.

Transcutaneous values are representative of the carbon dioxide and oxygen levels in the blood. The values at tissue level will **not** be the same as those measured arterially because of the transcutaneous nature of the measurement. However, provided that the transducer is properly handled by following the procedures described in this chapter, the transcutaneous values will *correlate with* (track closely) the arterial values. For example, a drop in transcutaneous values will usually indicate that arterial values have dropped as well.

Note that transcutaneous values will not always correlate with blood samples taken from the capillary blood of the heel (*heelsticks* or *astrups*).

For information on “Correlation of transcutaneous with arterial blood gas values”, see references 5, 6 and 7 in Appendix on Analog Output)

Setting up the Module

The optimum application period for the transducer at one site on a patient is dependent on the transducer temperature and on the sensitivity of the patient's skin. Before calibrating the transducer, (see the section *Calibrating the tcpO2/tcpCO2 Transducer* in this chapter) you should adjust the transducer temperature and also set the Site Timer.

Warning

Transducer Temperature

The temperature should be selected according to the patient’s age, weight and physical condition.

Available temperatures for the transducer are 37.0°C, 41.0°C, 41.5°C, 42.0°C, 42.5°C, 43.0°C, 43.5°C, 44.0°C, 44.5°C and 45.0°C. Usually, a higher transducer temperature results in both a better correlation and also a shorter time delay between a change in arterial blood gas and its detection by the transducer. However higher temperatures also increase the risk of skin burns. A temperature between 42° and 44°C is preferred by most physicians.

Note—The $tcpO_2$ / $tcpCO_2$ module is equipped with a temperature limiter which prevents the sensor temperature from exceeding 46ºC. If the temperature limiter fails, the following INOP message is displayed on the monitor:

- tc EQUIP MALF.

Site Timer

The Site Timer helps you to guard against the risk of skin burn by ensuring that the transducer is used at one site for no longer than a predefined period. The transducer can be set to operate for any of the following time periods: 0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 7 or 8 hours. The selection is visible in the task window next to “`Site Time##,` and the time remaining before the Site Timer expires appears next to “`Time Left:`”.

Site time settings should be adapted to the patient's skin sensitivity.

After the selected period of time has expired, an INOP message "tcCHANGE SITE" is displayed and the INOP tone is sounded. The Monitor can be configured either to switch off the transducer heating when the Site Time has expired, or to continue monitoring. This should be set as required by your hospital's policy, either by your biomedical engineering department or by the Philips Service Engineer.

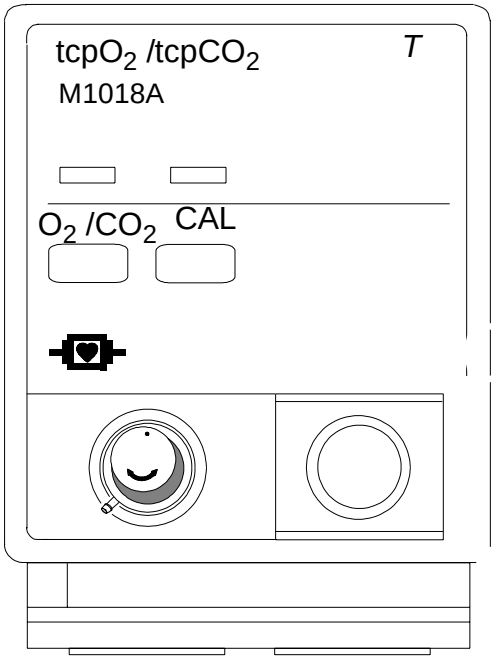
If the choice **Off** is available along with the above site times, you can choose to disable the Site Timer so that no "CHANGE SITE" reminder is displayed and the transducer monitors (and heats) indefinitely. Availability of this choice will depend on your hospital's policy and can be set by your biomedical engineering department or the Philips Service Engineer.

Correction for $tcpCO_2$ Values

Transcutaneous pCO_2 values tend to be higher than arterial values (due to the metabolic processes of the skin and the effect of heating on the blood under the transducer). This effect can be compensated for by selecting the *Severinghaus* correction in a special *Configuration Mode* on the monitor. (This has been selected if "corr." appears under the value for $tcpCO_2$ in the Task Window - consult your biomedical engineering department or the Philips Service Engineer if you wish to add or remove this correction.)

- The front of the module has two keys:
  - The **O2/CO2** key for parameter setup. A light will appear above the key when you are in setup.

– The CAL key to start calibration procedures.



The $tcpO_2/tcpCO_2$ Module

Note—The "T" on the front of the module indicates that this module transfers parameter settings from one monitor to another.

Symbols to Indicate Key Functions

As detailed in the table below, some versions of this module now use symbols, instead of words, to indicate the function of some keys. If the monitor's Reference Manual tells you, for example, to select the CAL key, you should press the key marked with the corresponding "calibration" symbol.

The design change also means that you will now find the module's product number on the rear of the module's housing, not on the front. Although the new modules do not show the letter "T" on the housing, all modules retain their capability to transfer parameter settings from one monitor to another.

Symbol	Name	Function	Which Modules?
	Cal	calibrate	SvO_2 (M1021A), $tcpO_2$/$tcpCO_2$ (M1018A) Mainstream CO_2 (M1016A)

Activating the Transducer

Follow the 24 hour activation procedure if:

- the electrolyte in your transducer has dried out (this occurs when the transducer has been out of use for a long period),
- or you are about to use a new transducer (new transducers are shipped dry).

Activate by following the *Remembraning the Transducer* procedure, then leave the transducer in a safe place for 24 hours, unplugged from the module and with the cap on. Remembrane the transducer again just before carrying out the calibration procedure.

Preparing the transducer

There are three steps to preparing a transducer for application to a patient.

First, remembrane the transducer.

Then, calibrate the transducer (first checking the module settings - Site Time, Transducer Temp and Alarm Limits).

Finally, prepare a site and apply the transducer to your patient.

The procedure for carrying out these steps is described in the following three sections. Each section gives guidelines on **when** you should carry out each step. Follow the procedures carefully to ensure best results.

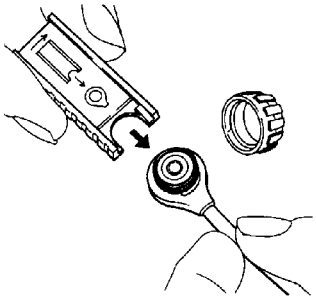
1. Remembrane the $tcpO_2$/ $tcpCO_2$ Transducer

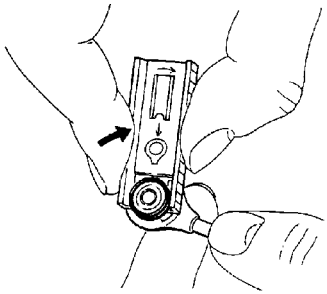
With normal use, the membranes will last approximately 1 week before a change is required. Change the membrane on the transducer if:

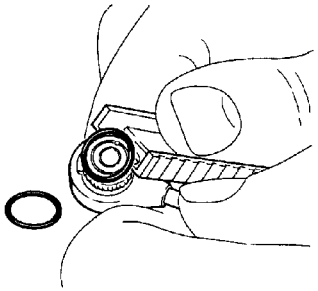
- you are about to use a new transducer,
- the transducer is to be used with a new patient,
- the membranes of the transducer are damaged (scratched or wrinkled),
- the transducer has been used for 5 days continuously,
- the transducer has been in storage for up to 28 days,
- you have a transducer which must be remembraned after activating for 24 hours (see previous page, *Activating the Transducer*), or
- calibration has failed **twice**.

1. Check that you have the Philips tc Accessory Kit containing an O-ring remover, absorbent paper, electrolyte solution and membrane replacers.

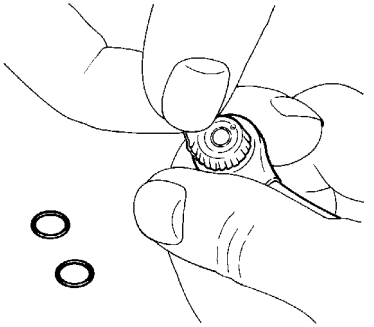
2. Unscrew the protection cap from the transducer, then hook the *O-ring remover* under both O-rings to remove them.

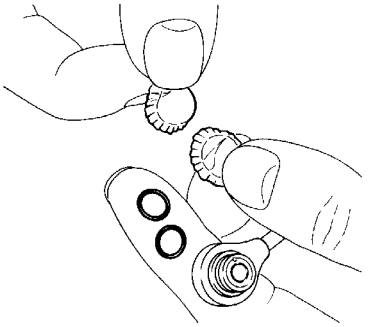




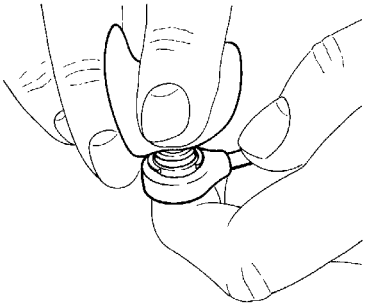


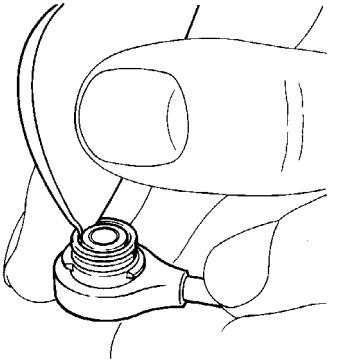
3. Remove **both** of the clear plastic membranes using your fingers.



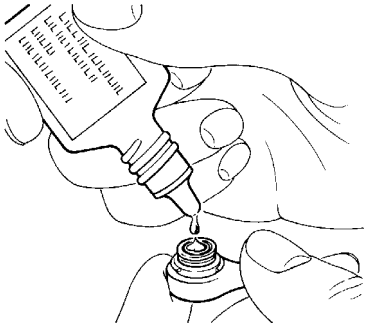


4. Clean the transducer head with *absorbent paper*. Make sure you clean the groove in the head and also the rim around the head to remove any old electrolyte - all of the old electrolyte must be removed to ensure a successful calibration and reliable measurements.

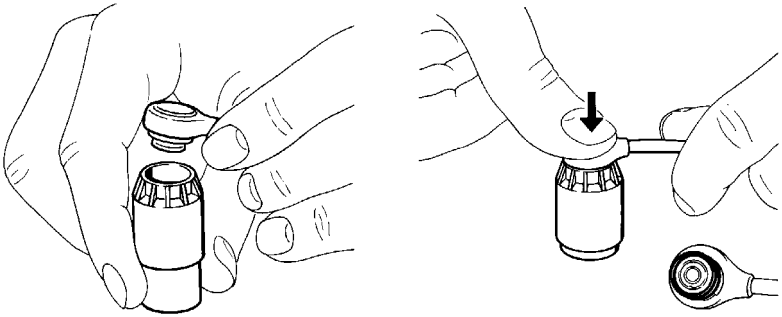




5. Apply *electrolyte solution* to the transducer head (approximately two drops). Break any air bubbles in the electrolyte using the nozzle of the solution container.



6. Press the transducer head downwards into an unused *membrane replacer* until the replacer retracts as far as it can and a *click* is heard. Discard the used replacer.



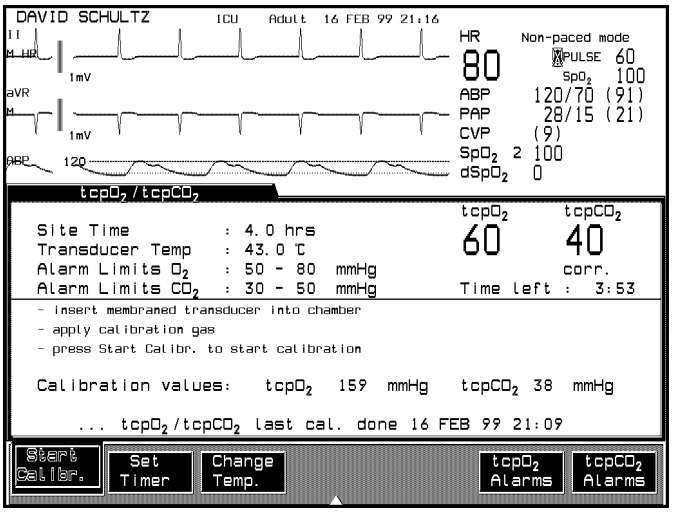
7. Remove any surplus electrolyte solution on the outside of the membranes with a soft tissue.

8. Examine the transducer carefully to ensure that the new membranes are secured by two O-rings on the transducer. If any air bubbles are visible under the membranes, repeat this procedure - air bubbles will cause incorrect readings.

Provided that you do not need to activate the transducer for 24 hours (see the section *Activating the Transducer* on page 20-7), the transducer is now ready to be calibrated and can be placed in the calibration chamber on the front of the module - see the next section.

2. Calibrating the $tcpO_2$/ $tcpCO_2$ System

Module Setup --> **tcpO2/tcpCO2**



Calibration of your $tcpO_2$/$tcpCO_2$ system is **required** if:

- you have just fitted a new membrane,
- you have just changed the transducer operating temperature, or,
- the INOP message tc CAL REQUIRD appears on the screen.

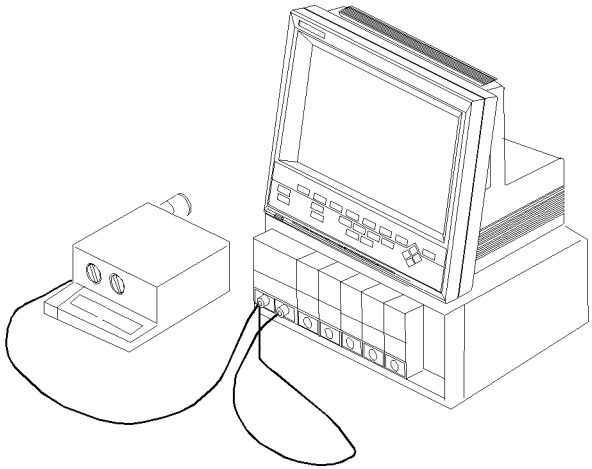
Note—To maintain accuracy, the $tcpO_2$ /$tcpCO_2$ transducer should be calibrated regularly, even if the CMS, V24 or V26 monitor does not prompt you to do so.

Calibration of your $tcpO_2$/$tcpCO_2$ system is **recommended** if:

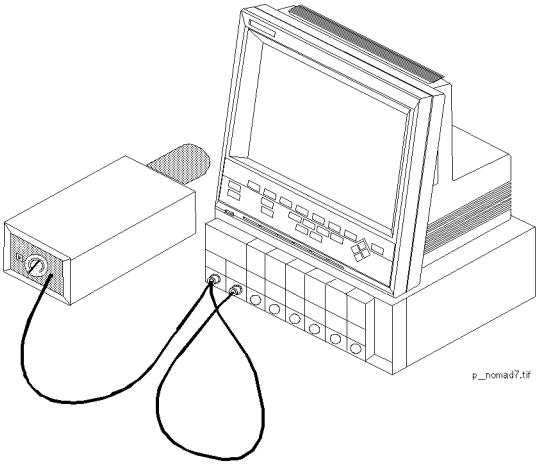
- the accuracy of the measurement is in doubt,
- you are about to start a new monitoring period, or
- you are about to change the measurement site, or
- at least six hours have elapsed since the last calibration

1. Check that you have a tcpO2/tcpCO2 module (inserted at the extreme left position in the rack for best accessibility) and a Philips Calibration Unit (15210B). The Calibration Unit must have a gas cylinder inserted in the rear and a pressure indicator reading that is above the out-of-gas zone (*black* on 15210B and *red* on Radiometer TCC3 Calibration Unit).

2. Check that the transducer is plugged into the module and that the transducer is inserted into the calibration chamber on the front of the module (swing the flap back and insert the transducer, then swing the flap over the transducer).



V24 Monitor with 15210B Calibration Unit



V24 Monitor with Radiometer TCC3 Calibration Unit

3. Press **Module Setup**, followed by **tcpO2/tcpCO2** to bring up the $tcpO_2$/$tcpCO_2$ Setup Task Window. (You can also reach this screen by pressing **O2/CO2** on the front of the module.)

4. Check the module settings as displayed on the screen - Transducer Temp., Site Time and Alarm Limits. You can change any of these values by pressing the appropriate softkeys (see the CMS, V24 or V26).

5. Fit the gas tubing from the Calibration Unit into the inlet on the side of the calibration chamber (the other end of the tubing must be fitted into the Calibration Unit).

6. If you are using a 15210B Calibration Unit, turn the timer control dial on the Calibration Unit clockwise as far as you can and press **Start Calibr.** on the Monitor. If you are using a Radiometer TCC3 Calibration Unit, press the button with the green arrow on the front of the calibration unit once, then press **Start Calibr.** on the monitor.(You can also start the calibration by pressing the CAL key on the front of the module until the light above the key

comes on and a tone sounds. In addition, a calibration can be **restarted** by pressing **Start Calibr.** .)

7. Wait for "...$tcpO_2$/$tcpCO_2$ calibration running" to be replaced by "...$tcpO_2$/$tcpCO_2$ calibration complete" in the task window (the calibration process generally takes 3 to 10 minutes but may take up to 20 minutes). For 15210B Calibration Units: If the timer control dial has not reached the start position when "...$tcpO_2$/$tcpCO_2$ calibration complete" is displayed, you can save gas by turning the dial counter-clockwise to the start position. For Radiometer TCC3 Calibration Units: If the green light on the front of the Calibration Unit is still flashing when "...$tcpO_2$/$tcpCO_2$ calibration complete" is displayed, you can save gas by pressing the button with the green arrow again.

When calibration is complete, the transducer is ready to be applied to a patient - see the next section. The Site Timer will start when you remove the transducer from the calibration chamber.

Apply the transducer to your patient as soon as possible after the "...calibration complete" message appears on the screen. If you wait longer than 30 minutes, the heat supply to the transducer is automatically switched off in order to prevent the electrolyte from drying out. This means that a new calibration will be required.

Trouble-shooting-Calibration Failure

If the calibration is unsuccessful, the message "...tcpO_2/tcpCO_2 transducer or Cal Unit malf" is displayed in the task window. In addition, the CAL FAILED INOP message for tc, tcpO_2 or tcpCO_2 appears in the upper left corner of the screen. Perform each of the following steps in the order specified until calibration is successful:

1. Check the Calibration Unit, then recalibrate, remembering to turn on the gas supply on the Calibration Unit. (If the pressure indicator reading is in the out of gas zone, there is insufficient gas in the cylinder. The gas tubing must be firmly connected to the Calibration Unit and to the calibration chamber on the module.)

2. If Step 1 is unsuccessful, check whether you need to **activate** the transducer (necessary if the electrolyte has dried out or if you have a new transducer, see page 24-6). Then remembrane the transducer ensuring that you:

   a. remove the old membranes, and
   b. clean the transducer head thoroughly.

   Then calibrate a second time.

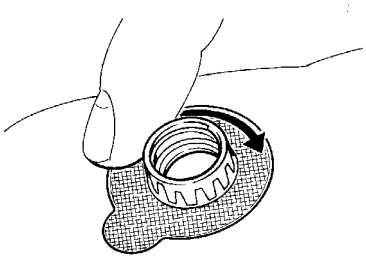
3. If Step 2 is unsuccessful, calibrate again. (A second calibration may be required in order to *stabilize* the electrochemical system in the transducer.)

4. Only if the above steps are unsuccessful (you have activated and remembraned the transducer and calibration has still failed twice), replace the transducer.

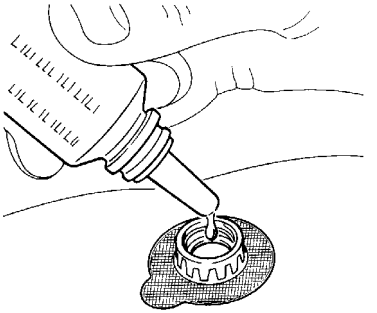
3. Applying the Transducer to the Patient

To apply the transducer to your patient, use the following procedure:

1. Check that you have the Philips Fixation Kit containing a box of fixation rings and contact fluid.
2. Select a measuring site and clean the skin with alcohol solution. (To optimize the measurement, select a site with high capillary density and blood flow, thin epidermis and no cardiovascular disorders. Most physicians use the abdomen, chest and back.)
3. Take a *fixation ring* from the box and peel off the protection film to reveal the sticky surface.
4. Apply the fixation ring to clean and dry skin by pressing the ring onto the site with a finger, first in the center and then around the outside to ensure a good seal. (A good seal between the fixation ring and the skin is essential for good results.)

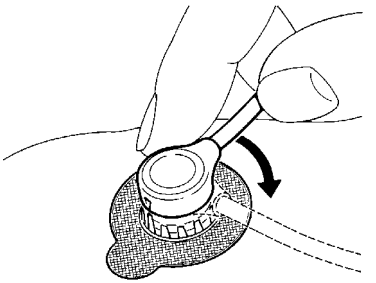


5. Place 3 to 5 drops of *contact fluid* in the center of the ring.



6. Remove the transducer from the chamber (the Site Timer on the screen will start) and align the arrow on the transducer either with or opposite the tab on the ring.

7. Turn the transducer a quarter-turn clockwise to fasten it to the ring.



8. Wait 10 to 20 minutes for readings to stabilize. (The $tcpO_2$ and $tcpCO_2$ numerics are displayed on the standard display.)

Restarting the Site Timer

- The Site Timer is automatically restarted after the transducer has been calibrated and removed from the calibration chamber (calibration is recommended whenever the site is changed).
- You can restart the Site Timer up to 2 hours after the time period has expired. (After this 2 hour period a calibration is required.) Press **Site Timer** to enter the Site Timer task window. *Confirm* your required time.

When changing the application site after a measuring period, some users leave the fixation rings in position. This allows the transducer to be quickly moved from site to site.

Note— During the initial 3 minutes of use, $tcpO_2$/$tcpCO_2$ alarms are suspended to eliminate false alarms. During this period, the "STABILIZING" INOP message is displayed for tc, $tcpO_2$ or $tcpCO_2$. After the transducer has been attached to the skin, the instrument reading will slowly assume a steady value. The reading will stabilize as soon as the measurement site is warmed up and local hyperemization is completed; usually 10 to 20 minutes for the $tcpO_2$ reading and 3 to 7 minutes for $tcpCO_2$.

The $tcpO_2$/$tcpCO_2$ Setup Task Window indicates the amount of remaining time before the Site Timer expires. At the end of the site time the INOP message "CHANGE SITE" is displayed and the INOP tone is sounded. The Monitor will switch off the transducer heating **or** will continue monitoring, depending on how the Monitor has been configured.

Warning

- **Prolonged continuous monitoring may increase the risk of undesirable changes in skin characteristics, such as irritation, reddening, blistering or burns. If the Site Timer is Off (disabled) or automatic heating switch-off has been disabled, the transducer will heat indefinitely while on a patient. Ensure that the site is changed in accordance with standard medical procedures in your hospital.**
- **Always unscrew the transducer from the fixation ring before removing the fixation ring from the skin.**
- **When defibrillating a patient, it is important to either:**

- **remove the transducer before defibrillating, or**
- **remembrane and calibrate the transducer after defibrillating**

Caution

- All specified transducers (but not membranes) are protected against the effects of the discharge of a defibrillator.
- To avoid transducer damage, remove it from the patient during high frequency surgical procedures.

$tcpO_2$/$tcpCO_2$ Alarms and INOP Messages

The $tcpO_2$/$tcpCO_2$ alarm messages are rated in order of severity:

** Yellow
INOP message

Alarm tone = a single tone repeated every second
INOP tone = a single beep repeated every 2 seconds.

Physiological Alarms

Alarm Message	Condition	Visual Indication	Audible Indication
`tcpO2 90>80`	$tcpO_2$ above high alarm limit	$tcpO_2$ numeric blinks. Yellow alarm lamp.	Alarm tone
`tcpO2 40<50`	$tcpO_2$ below low alarm limit	$tcpO_2$ numeric blinks. Yellow alarm lamp.	Alarm tone
`tcpCO2 60>50`	$tcpCO_2$ above high alarm limit	$tcpCO_2$ numeric blinks. Yellow alarm lamp.	Alarm tone
`tcpCO2 20<30`	$tcpCO_2$ below low alarm limit	$tcpCO_2$ numeric blinks. Yellow alarm lamp.	Alarm tone

Technical Alarms

INOP messages appear when the monitor cannot measure or process signals properly or when the measuring site is to be changed. For transcutaneous gas measurements all INOP messages except CHANGE SITE and CHECK TIME relate to equipment-related problems but you must check the patient's condition first. If the INOP message is accompanied by an audible alarm, it can be silenced with the **Silence/Reset** key.

INOP Messages

INOP Message	Condition	Visual Indication	Audible Indication
`tc UN-PLUGGED`	Parameter switched on and unplugged from rack. Silencing the alarm switches the parameter off.	$tcpO_2$/$tcpCO_2$ numerics display -?-.	INOP tone
`tc EQUIP MALF`	Malfunction in the transducer or module.	$tcpO_2$/$tcpCO_2$ numerics display -?-. Prompt message appears in task window.	INOP tone
`tc NO TRANSDUC`	No transducer is connected to the $tcpO_2$/$tcpCO_2$ module. Silencing the alarm switches the parameter off.	$tcpO_2$/$tcpCO_2$ numerics display -?-.	INOP tone
`tc CHANGE SITE`	Site Timer has timed out	$tcpO_2$/$tcpCO_2$ numerics may display -?- depending on configuration. Prompt message appears in task window.	INOP tone

INOP Message	Condition	Visual Indication	Audible Indication
tc CAL FAILED[1]	Calibration failed due to out of range or unstable signal during calibration.	$tcpO_2$/$tcpCO_2$ numerics display -?-. Prompt message appears in task window.	INOP tone
tc CAL REQUIRD	Calibration is required before applying the transducer to the patient[2]	$tcpO_2$/$tcpCO_2$ numerics display -?-. Prompt message appears in task window.	INOP tone
tc CAL RUNNING	The $tcpO_2$/$tcpCO_2$ calibration is running.	Numerics display -?-. Prompt message appears in task window.	None
tc STABILIZING	The transducer has not yet reached the selected temperature and/or skin hyperemization is not yet complete.	$tcpO_2$/$tcpCO_2$ numeric is displayed with ? to indicate that values are unstable.	None
tc CHECK TIME	Site Timer due to time out (15 minutes or less)	None	None

[1]See “Troubleshooting - Calibration Failure” earlier in this chapter or the CMS, V24 or V26 User’s Guide.

[2]Possible module or transducer malfunction if calibration in progress.

Parameter Settings Transfer

The following parameter settings can be transferred with $tcpO_2$/$tcpCO_2$ modules. For more information on Parameter Settings Transfer, refer to "*Parameter Settings Transfer*," Chapter 3.

Setting Name	Meaning
Alarm limits	$tcpO_2$ and $tcpCO_2$ high and low alarm limits
Site Time setting	Period transducer will be active at one site
Transducer temperature	Temperature to which transducer is heated

Recalibration of the $tcpO_2$/$tcpCO_2$ system is required if the module has been transferred.

Accessories and Ordering

You can order parts and accessories from Philips supplies at www.medical.philips.com or consult your local Philips representative for details.

Warning

Reuse: Never reuse disposable transducers, sensors, accessories and so forth that are intended for single use, or single patient use only.

Philips' approval: Use only Philips-approved accessories.

Packaging: Do not use a sterilized accessory if its packaging is damaged.

This symbol indicates that the specified transducer (but not its membranes) is designed to have special protection against electric shocks (particularly regarding allowable leakage currents), and is defibrillator proof.

Description	Part No.
12x tc Accessory Kit (O-ring remover, absorbent paper, electrolyte solution, replacement membrane)	15209-60010
tc Application Kit (4x25 disposable fixation rings, 4x20ml contact fluid)	15209-60020
Calibration gas - 6 gas bottles	15210-60010
Calibration gas - 6 gas bottles (Europe and Japan only)	15210-64010
Replacement tubing (5 tubes)	M2205A
$tcpO_2/CO_2$ transducer	M1918A
Calibration unit	15210B
Radiometer TCC3 calibration unit (available from Radiometer)	n/a